Do I need to validate the responses I have mentioned below such as users ranking features 8 out of 10 and reporting increased motivation?

# **Evaluation**

This chapter provides an evaluation of the application, analysing the impact the application had on motivating pro-environmental behaviour change by motivation levels and realisation of a reduction in individual carbon footprints, through the gamification principles applied. To evaluate the application, questionnaires about participants motivation levels were carried out before and after using the application, as well as analysing any change in participants’ carbon footprint scores over time.

## **Questionnaire Responses**

Before trialling the application, participants were asked to answer questions relating to their motivation to reduce their individual carbon footprint and provide reasons for their level of motivation. A copy of the questionnaire is attached in the appendix at the end of this report, namely appendix 1. The results of the responses from the 10 participants revealed that of the 10 participants, only 2 responded with a motivation level of 3 or more prior to using the application. Popular reasons for such little motivation were a feeling of negligible individual impact, difficulty in seeing the benefit or consequences of your environmental actions and a feeling of no personal reward in return for sacrifices or changing your environmental actions.

After 11 days of using the gamified, social mobile app in this project, participants were again asked to answer questions about their motivation levels. The results indicate that of the 10 participants involved in this study, after using the gamified social mobile app, 6 participants reported increased motivation levels, between the ranges of 5-8 out of 10 for their level of motivation. This is an increase in motivation levels above 3 out of 10 from 2 to 6 participants, a 200% increase.

When asked to respond as to why their level of motivation had or had not increased, participants responded by saying the feeling of mutual accountability in the cooperation aspect of the game, the team leaderboard, was a source of motivation. In this case, participants attributed this motivation to the feeling of a social etiquette, and responsibility to not let your teammate down, and that helping the environment was not the reason for wanting to reduce individual carbon footprints. Participants further divulged that by viewing their individual scores over time they could visually see their performance, motivating them to improve their scores, or not to decline in scores.

With the ability to view the breakdown of their daily emission logs, participants reported these breakdowns to facilitate learning, aiding them in reducing their carbon footprints where one user reported changing his commute to training from driving solo, to carpooling with a teammate. Another user reported after realising the carbon footprint produced by consuming beef in comparison to chicken, decided to substitute beef for chicken for his dinner on two occasions.

When asked about their overall experience using the app, all 10 participants reported running into no errors in the application, felt the most frequent tasks could be completed quickly and that no task was overly complex.

When asked about their overall experience, all participants reported enjoyment using the app, referencing the clear layout and navigation of the app to be very user friendly and easy to use.

## **Changes in Carbon Footprint Scores**

While the questionnaires provided insights into whether users felt an increase in motivation to reduce their individual carbon footprints, and why, the realised carbon footprint scores of the participants, that is, the tangible reduction, increase or consistency in their carbon footprints, provides insights into whether meaningful action was taken, or did participants only feel motivation but did not actually take meaningful action by reducing their carbon footprints.

Upon analysing the data, 3 out of 10 users exhibited a realised decrease in their individual carbon footprints between the first and last days’ carbon footprints. Although the other participants did not deliver a reduced carbon footprint, the results indicate that the gamified social mobile app in this project lead to a reduction in 30% of participants’ carbon footprints. In terms of actual carbon footprint reduction levels, the realised difference between their worst and best carbon footprint score was 2.57kg, 3.8kg, and 2.9kg of carbon dioxide equivalent, representing an overall decrease of 14%, 23% and 19% in their carbon footprints respectively. Upon analysing the breakdown of these scores, to reduce these scores, users began to carpool or substitute beef for a different source of meat such as chicken or turkey.

## **Requirements**

The requirements outlined in the design section in chapter 2 of this report were split into 2 categories: functional and non-functional requirements. The below 2 sections discuss whether these requirements were met.

### **Functional Requirements**

The functional requirements outlined in chapter 2, the design chapter, were:

* **To sign in**
  + Users have the ability to sign in to the app using their login credentials. If invalid credentials are entered, the user will not progress to the home screen because no matching authenticated user will be found in the database. Upon entering invalid credentials, the user will receive an alert explaining which part of the credentials are incorrect, the email, password, or both. This functional requirement **has been met**.
* **To log food emissions**
  + From the homepage, users can click the log emission button, and from there select the food option. On the log food screen, users can select their source of food, the portion size and the unit of measurement, such as grams, pounds, ounces or millilitres, catering for a variety of different users’ preferences. As such, this functional requirement **has been met**.
* **To log transport emissions**
  + Similarly to logging food emissions, users click the log emission button from the homepage, except this time select transport. On the transport screen, users select their mode of transport, the distance travelled and the unit of distance, either kilometres or miles. If a car is selected, the user is prompted to provide the size and fuel type of the car. Therefore, this functional requirement **has been met**.
* **To view history of logs for the current day and their co2e contribution**
  + To view the breakdown of their carbon footprint for the current day, users can view the history of their logs on the homepage. This breakdown is further illustrated through a pie chart on the homepage. From this, this functional requirement **has been met**.
* **To compete in individual leaderboard**
  + At the end of each day, a score is generated for each user based on their emission logs for that day. Users can view their scores in the individual leaderboard by selecting the second tab in the navigation bar. To speed up locating your position in the leaderboard, the logged in user’s position is highlighted in green. Thus, this functional requirement **has been met**.
* **To compete in team leaderboard, cooperating with teammate**
  + Exactly like the individual leaderboard, using this score, combined with the score of their paired teammate, the user can view their position in the team leaderboard by selecting the third tab of the navigation bar, with their position being highlighted in green. This functional requirement **has been met.**
* **To view individual progress chart illustrating individual’s carbon footprint scores over time**
  + At the end of each day when a score is generated for each user, this score is added to the users’ individual history or my scores tab on the navigation bar. This is the last tab, the fourth tab on the navigation bar. By selecting the fourth tab, users can view their performance or history of scores over time, and see if they have been improving, facilitating self-competition. This functional requirement **has been met**.

### **Non-functional Requirements**

The non-functional requirements outlined in chapter 2, the design chapter were:

* **Cross-functional application**
  + Having implemented the application in React-Native the application is cross-functional and thus this non-functional requirement **has been met**. Android and iOS users are able to use the app, catering for either phone provider.
* **Easy to use application**
  + Results from participants’ answers in the questionnaire revealed all participants enjoyed using the app, referencing the clear layout and navigation of the app to be very user friendly and easy to use. Thus, this non-functional requirement **has been met**. This result has been achieved through a clear navigation bar, tidy, minimal screens and explanatory text on screen such as alerts.
* **Frequent tasks are performed quickly** 
  + All users were asked in the questionnaire to rank the speed at which frequent tasks could be complete on a scale from 1-10. The results from this were an average score of 8 out of 10, 10 being the tasks were completed as fast as they could imagine, 1 being terribly slow. A score of 8 out of 10 is well above average, thus this non-functional requirement **has been met**. This score has been achieved through the implementation of the navigation bar and the emission log button being pinned to the bottom of the home screen being accessible from any position on this screen.
* **Complex tasks are broken down to reduce complexity**
  + When asked to rank the complexity of the app on a scale of 1 – 10, participants provided an average ranking of 2 out of 10, with 10 being extremely complex and 1 being very simple. Having received the second best ranking for complexity, this non-functional requirement **has been met**. To reduce complexity and thus achieve this satisfying score for application complexity, users can select from different units of measurement such as grams, pounds, ounces and millilitres when logging food emissions and from kilometres or miles when logging transport emissions. Additionally, a history of emission logs for the current day are displayed on the homepage and alert messages are provided for incorrect login attempts.
* **Reduced likelihood of user errors**
  + Insights from participant feedback on their experience with making mistakes and running into errors using the application reported in a score of 3 out of 10, with 10 signifying always making mistakes and running into errors. Having achieved a well above average score, this non-functional requirement **has been met.** The features reducing the likelihood of errors for the application are displaying the history of logs on the homepage, and the confirmation button which appears when a user attempts to log an emission.

## **Testing**

To test the application, console logs were frequently used to view any discrepancies between expected and actual performance. By strategically inserting console log statements throughout the code base, the author was able to pinpoint the location of any bugs in the code, aiding the speed at which these bugs could be resolved. Console logs were particularly useful when the code needed to wait for data to be retrieved from the database before proceeding.

Figure 1 below illustrates an example of the codebase where the author utilised console logs for testing purposes when retrieving information from the database. In figure 1, the author was expecting the console, or terminal, to log the sequence “123”, however, as can be seen from figure 2 below, the sequence was in fact “132”. This allowed the author to pinpoint the problem which was that the code was not waiting for the data to be retrieved. By utilising console logs for testing this function, the author was able to remedy the code as illustrated in figures 3 and 4 below with the improved code and the desired sequence of “123”.

A picture containing graphical user interface

Description automatically generatedGraphical user interface, text, application

Description automatically generated

Figure 2: Output from running code in figure1. Sequence expected is 123, but actual output was 132. Thus, a bug has been identified.

Figure 1: Example of testing code using console logs. The sequence printed should be 123.

A picture containing graphical user interface

Description automatically generatedGraphical user interface, text, application

Description automatically generated

Figure 4: The sequence printed from figure 3, illustrating that the bug has been fixed since the sequence 123 matches the desired output.

Figure 3: Updated code where “await Promise.all(…” has been added. Again, the expected output should be 123.

## **Conclusion**

By analysing the questionnaire responses before and after using the app, and by analysing the change in realised carbon footprint scores over time while using the application, this chapter has evaluated the application and proven to be an effectful application. 30% of participants reported increased motivation to reduce their individual carbon footprint after using the application, and 30% of participants were found to have a realised, tangible reduction in their carbon footprint over time. The functional and non-functional requirements for the application have been met, justified by responses from the data collected from users through the questionnaires. By implementing the use of console logs, the author was able to test the application, leading to the resulting positive evaluation.

# **Appendix**

Attach copy of questionnaire here